Appendix 1

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I. Field methods

Our field methods for documenting population size and reproductive statistics in New York (Murphy 1983, 2001) and Oregon (Redmond et al. 2009, Murphy et al. 2020) have remained unchanged over the period of study in New York. Briefly, daily surveys of the populations were conducted on foot, from vehicles along roads dissecting study sites, and from canoes on both Charlotte Creek and the Donner und Blitzen River beginning in mid to late May. Female kingbirds build conspicuous nests in trees (Murphy et al. 1997) and nests of most pairs were found prior to egg-laying (~80%). Nest checks occurred at 2 to 3 -d intervals, but more frequently as hatching and fledging neared, which allowed documentation of laying date, clutch size, egg size, and nesting success. When placed in trees over land, most nests could only be accessed by using either using ladders or climbing trees. Contents of the highest nests (>10 m) could generally only be viewed using a mirror attached to an extensible pole. Nest placed in trees over water were lower in the tree and were often accessible from a canoe, by wading in the water, or sometimes from ladders placed in the water.

Breeding date of each clutch, defined as the day the first egg was laid, was known for most nests by direct observation, and for others was backdated from hatching dates (assuming 1 egg laid/day and an incubation length of 15 days; Gillette et al. 2021) or by comparisons of young to nestling growth curves (Murphy 1981). Egg mass (nearest 0.1 g; Pesola scale) and maximum length and breadth (nearest 0.05 mm; dial calipers) were measured in all years except

2009. In some years eggs were weighed and measured on the day they were laid, but most were not measured until the full clutch was present. Fresh egg mass (i.e., mass recorded within a day of the egg's laying) was estimated for eggs weighed more than two days after laying by using maximum length (L) and breadth (B) measurements of eggs using the formula Mass = $C*(L*B^2)$, where C (= 0.545) was determined from measurements of eggs weighed on the day of laying (Murphy 1983a). Identical data were collected from renesting attempts, but with only one exception (length of laying season), in this paper we limited all analyses to initial nests of the season. Observations of banded birds at both sites showed that pairs essentially never changed breeding locations after an initial nest failure. We thus assumed for all pairs that a nest appearing at a site after a failure was produced by the pair that nested there initially.

II. Geographic, annual and seasonal variation in reproduction

To test for intrasite annual variation in breeding date (i.e. date of the laying of the clutch's first egg) and clutch size we used analysis of variance (ANOVA) of individual clutches. Date was counted continuously from the start of May (May 1 = 1, June 1 = 32). For each year we then calculated annual means for breeding date and clutch size of initial clutches, length of the laying season (= breeding date of last replacement nest – breeding date of first initial clutch), breeding synchrony (number of days elapsed between the 10^{th} and 90^{th} percentile of breeding dates of initial clutches), and rate of the seasonal decline of clutch size (= slope of regression of size of initial clutch size against breeding date). Comparisons between sites were made using *t*-tests.

Both breeding date and clutch size differed among years at both sites (Table A1.1), while the only trait to not differ between sites was the rate at which clutch size declined seasonally (Table A1.1). EAKBs began to lay 12 days later, on average, in OR than NY, but at both, the range of laying dates of individual clutches extended over a six-week period. In any given year, however, most initial clutches were laid within an approximate 2-week+ window (= breeding synchrony) that was nonetheless shorter in NY (Table A1.1). Length of laying season, which included replacement nests, was one week longer in NY (Table A1.1), while clutch size was larger in OR despite the later start to breeding (Table A1.1).

Despite site differences in clutch size (Table A1.1), annual variation in clutch size within sites was associated with mean annual breeding date in near identical fashion at both sites (Figure A1.1). Similarly, at both sites larger clutches were laid in years when mean egg mass was large (Figure A1.2). Egg size is highly repeatable within females in Eastern Kingbirds (Murphy 2004) and thus little annual variation is expected. However, Murphy (1986) showed that large eggs are laid in years of high food abundance and thus the positive association between mean annual clutch size and mean annual egg mass likely reflects a positive response for both variables to favorable breeding conditions, most likely high food availability.

We also attempted to determine whether annual variation in mean breeding date was tied to ambient temperature during particular weeks prior to the initiation of breeding. We thus used correlation analysis to compare mean annual breeding date to mean daily ambient temperature averaged over a sliding 30-d window beginning with the 1st of April. Each subsequent time period shifted by 10 days so that the next period began on 11 April, then 21 April, and on to the last 30-d period beginning on 21 May. We refer to this as “prelaying temperature.” Results are given in Table A1.2. In New York, the strongest correlation existed between mean temperature averaged over the period 1 to 30 May, followed by the period between 11 May and 9 June (Table A1.2). Not surprisingly given the later breeding in Oregon than New York (Table A1.1), the strongest correlation between temperature and annual mean breeding date occurred roughly three weeks later (Table A1.2), with the next strongest correlation being between breeding date and mean temperature over the 30-day period starting on 11 May (Table A1.2).

Literature Cited

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TABLE A1.1. Summary of geographic and annual variation in breeding date, breeding synchrony, clutch size, length of the laying season, and seasonal rate of decline of clutch size of initial clutches for Eastern Kingbirds breeding in New York (1989-2000) and Oregon (2002-2011). Cell entries are mean ± SE (N). Statistical comparison of geographic differences (Student's *t*-test) reported in far-right column. Annual comparisons (analysis of variance) within sites reported below mean values for breeding date and clutch size.

Trait	New York (12 years)	Oregon (10 years)	*t* (*P*)
Breeding date	6 June ± 0.248 days (652) Range = 20 May to 30 June	18 June ± 0.369 days (452) Range = 31 May to 10 July	26.59 (<0.001)
	$F = 25.72$, $P < 0.001$	$F = 21.13$, $P < 0.001$	
Breeding synchrony	13.4 ± 0.81 days (12) Range = 10 to 20 days	17.2 ± 1.51 days (10) Range = 10 to 29 days	2.31 (0.032)
Length of laying season	45.2 ± 2.61 days Range = 29 to 57 days	37.6 ± 7.15 days Range = 26 to 46 days	2.17 (0.042)
Clutch size	3.23 ± 0.023 eggs (635) Range = 2 to 4 eggs	3.61 ± 0.031 eggs (438) A Range = 2 to 5 eggs	9.48 (< 0.001)
	$F = 2.03$, $P = 0.024$	$F = 3.16$, $P < 0.001$	
Rate of seasonal decline of clutch size	-0.041 ± 0.005 eggs/d (12) Range = -0.011 to -0.075	-0.045 ± 0.005 eggs/d (10) Range = -0.021 to -0.067	0.51 (0.618)

TABLE A1.2. Correlation coefficients (*r*) describing the relationships between mean annual breeding date (i.e. laying date of 1st egg of a clutch) of Eastern Kingbirds and ambient temperature in 30-d periods beginning with the 1st of April. Time periods shift in successive 10-d intervals. The period in which temperature showed the strongest correlation with laying date is in bold.

Period	New York; *r* (*P*)	Oregon; *r* (*P*)
1 to 30 April	-0.431 (0.141)	-0.327 (0.357)
11 April to 10 May	-0.332 (0.268)	-0.164 (0.650)
21 April to 20 May	-0.551 (0.064)	-0.186 (0.608)
1 to 30 May	**-0.913 (0.000)**	-0.656 (0.040)
11 May to 9 June	-0.656 (0.021)	-0.757 (0.011)
21 May to 19 June	-0.462 (0.131)	**-0.876 (0.001)**

Figure legends

Figure A1.1. Relationship between mean annual clutch size of initial clutches for each year in relation to the average clutch initiation date (= Breeding date) of initial clutches for Eastern Kingbirds breeding in central NY (open circles; $r^2 = 0.637$, $P = 0.002$) and southeastern OR (filled circles; $r^2 = 0.377$, $P = 0.059$).

Figure A1.2. Mean annual clutch size in relation to mean annual egg mass for Eastern Kingbirds breeding in central NY (open circles; $r^2 = 0.300$, $P = 0.065$) and southeastern OR (filled circles; $r^2 = 0.467$, $P = 0.029$).

Figure A1.1

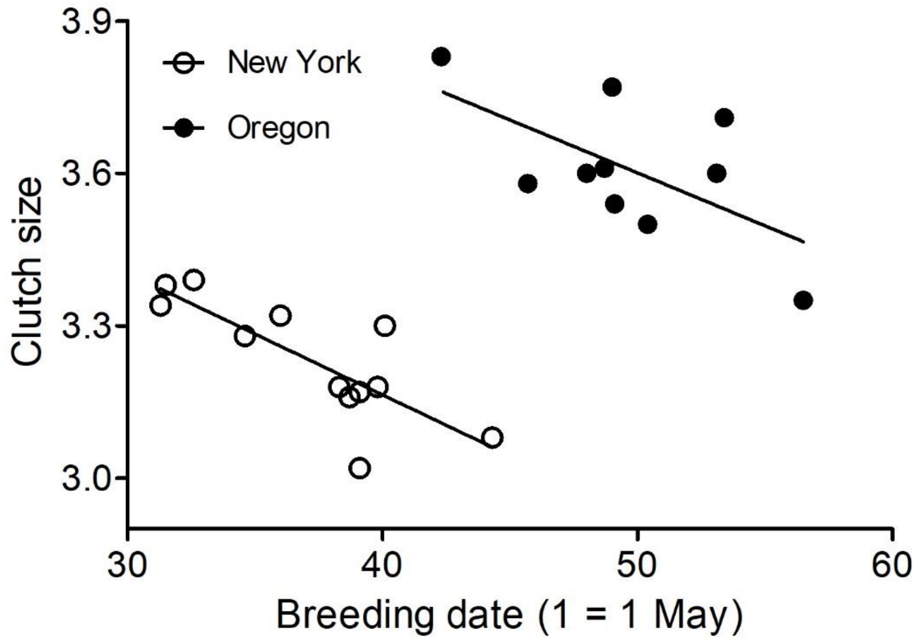
3.9
3.6
3.3
3.0
Clutch size
New York
Oregon
30
40
50
60
Breeding date (1 = 1 May)

Figure A1.2